

What is claimed is:

1. A display device, including a pair of substrates opposed to each other and provided with electrodes, at least one of substrates is light-transmissive
5 and at least one surface of the substrates is provided an electrode, a spacer disposed between the substrates for retaining a space having a desired width, and at least one kind of group of electrostatic particles contained in the space between the substrates, the device being configured to display an image corresponding to an image signal voltage applied to the electrode of the
10 substrates by causing the group of particles to travel in the space between the substrates by an electric field produced by the image signal voltage, comprising:

a particle utilization-promoting means for preventing the number of particles contributing to the display from decreasing, the particle
15 utilization-promoting means provided so as to face the space in which the group of particles travel.

2. A display device, including a pair of substrates opposed to each other and provided with electrodes, at least one of substrates is light-transmissive
20 and at least one surface of the substrates is provided an electrode, a spacer disposed between the substrates for retaining a space having a desired width, and at least one kind of group of electrostatic particles contained in the space between the substrates, the device being configured to display an image corresponding to an image signal voltage applied to the electrode of the
25 substrates by causing the group of particles to travel in the space between

the substrates by an electric field produced by the image signal voltage, comprising:

a vibration-generating portion provided so as to face a space in which the group of particles travel.

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3. The display device according to claim 2, wherein the vibration-generating portion is provided on at least one of the substrates so as to face the space in which the group of particles travel.

10 4. The display device according to claim 2, wherein a first electrode and a second electrode to which the image signal voltage is applied are provided on one of the substrates.

5. The display device according to claim 2, wherein a first electrode is
15 formed on one of the pair of substrates and a second electrode is formed on the other one of the pair of substrates, the image signal voltage is applied between the first and the second electrodes.

6. The display device according to claim 2, wherein the
20 vibration-generating portion includes electrodes and a vibration generator that generates vibration by an electric field formed by the electrodes, and at least one of the electrodes constitutes the electrode provided on the substrate.

7. The display device according to claim 2, wherein the
25 vibration-generating portion includes electrodes and a vibration generator

that generates vibration by an electric field formed by the electrodes, and the vibration-generating portion constitutes the spacer.

8. The display device according to claim 7, wherein an insulation
5 medium is disposed between the electrodes of the vibration-generating portion and the electrodes provided on the substrate so that the vibration-generating portion is insulated from the electrodes of the substrate.

9. The display device according to claim 2, wherein the space in which
10 the group of particles travel is a gas phase space.

10. The display device according to claim 2, wherein the space in which the group of particles travel is a liquid phase space filled with an insulative solvent.

15 11. The display device according to claim 10, wherein capsules each containing the group of particles and the insulative solvent are disposed in the space between the substrates.

20 12. The display device according to claim 10, wherein the particles composing the group of particles are aligned by an electric field applied between the electrodes of the substrates according to the image signal voltage.

25 13. The display device according to claim 12, wherein the group of

particles are electric field-aligned particles aligning along the electric field.

14. The display device according to claim 2, wherein the group of particles are colored with at least one color.

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15. The display device according to claim 2, wherein the vibration-generating portion includes of a piezoelectric material.

16. The display device according to claim 2, wherein the
10 vibration-generating portion also serves as at least one of the substrates.

17. The display device according to claim 2, wherein:

a display operation in the display device includes at least a first and a second display states;

15 in the first display state, a first image signal voltage is applied to the electrodes provided on the substrates to form a first electric field;

in the second display state, a second image signal voltage is applied to the electrodes provided on the substrates to form a second electric field having a different direction from that of the first electric field; and

20 an application of a high-frequency sine wave to the vibration-generating portion and an application of the second image signal voltage to the electrodes provided on the substrates are carried out when performing rewriting from the first display state to the second display state.

25 18. The display device according to claim 17, wherein the application of

the high-frequency sine wave voltage and the application of the second image signal voltage are carried out simultaneously.

19. The display device according to claim 17, wherein the application of
5 the high-frequency sine wave voltage and the application of the second image signal voltage are carried out in different timing.

20. A display device for displaying an image corresponding to an image signal voltage applied between a pair of electrodes disposed in a space formed
10 between a pair of opposing substrates, at least one of which is transparent, by causing at least one kind of plural charged colored particles internally existing in the space to travel between the electrodes by an electric field produced by the image signal voltage, comprising:

a partition wall for partitioning the space into pixels;

15 a substrate-side electrode connected to a voltage applying means and provided on an inner surface of at least one substrate for each of the pixels; and

a partition wall-side electrode provided on the partition wall for each of the pixels and connected to the voltage applying means;

20 wherein the image signal voltage is applied to at least the substrate-side electrode to perform a display operation.

21. The display device according to claim 20, wherein the space is a gas phase space.

22. The display device according to claim 20, wherein at least one of an electric field formed by applying a voltage to the substrate-side electrode or an electric field formed by applying a voltage to the partition wall-side electrode is an alternating electric field.

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23. The display device according to claim 20, wherein:

the substrate-side electrode includes a pair of electrodes disposed on at least one substrates;

the substrate-side electrodes are connected to a first voltage applying means for applying the image signal voltage to the substrate-side electrodes; and

the partition wall-side electrode is connected to a second voltage applying means for applying a voltage that forms an electric field for preventing the charged particles from adhering to the partition wall to the partition wall-side electrode.

24. The display device according to claim 23, wherein the first voltage applying means applies the image signal voltage to the substrate-side electrodes, and thereafter, the second voltage applying means applies the voltage to the partition wall-side electrode.

25. The display device according to claim 23, wherein the image signal voltage application by the first voltage applying means to the substrate-side electrodes and the voltage application by the second voltage application means to the partition wall-side electrode are performed simultaneously.

26. The display device according to claim 23, wherein:

the charged colored particles include two or more kinds of particles having different charging characteristics and internally existing in the space;

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the second voltage applying means applies a voltage to the partition wall-side electrode, the voltage forming an electric field for preventing adherence to the partition wall of particles whose color is observed among the charged colored particles from a viewing side and determines a display color.

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27. The display device according to claim 23, wherein the first voltage applying means and the second voltage applying means are configured including a common power supply.

15 28. The display device according to claim 23, wherein the first voltage applying means and the second voltage applying means are configured including different power supplies respectively.

29. The display device according to claim 23, wherein the partition
20 wall-side electrode is electrically connected to at least one of the substrate-side electrodes.

30. The display device according to claim 29, wherein:

the first voltage applying means applies the image signal voltage to a
25 first electrode and a second electrode, which are the pair of electrodes

disposed on the substrates, to form an electric field directed toward the second electrode;

the second voltage applying means applies a voltage to the partition wall-side electrode electrically connected to the first electrode to form an electric field directed toward the second electrode; and

while the voltage is being applied to the second electrode, the voltage is applied to the partition wall-side electrode.

31. The display device according to claim 20, comprising:

one kind of charged colored particles internally exist in the space;

a colored layer exhibiting a different color from that of the particles and provided on the side of the substrate-side electrodes or the partition wall-side electrode; and

a voltage applying means provided for applying the image signal voltage between the substrate-side electrode and the partition wall-side electrode.

32. The display device according to claim 31, wherein:

a display operation in each of the pixels in the display device includes at least a first display state and a second display state;

in the first display state, the charged particles covers the surface of the colored layer provided on the side of the substrate-side electrode; and

in the second display state, the charged particles travel to the partition wall-side electrode to expose the surface of the colored layer.

33. The display device according to claim 20, wherein at least one of a voltage applied to the partition wall-side electrode and a voltage applied to the substrate-side electrode is configured by superimposing a DC voltage and a rectangular wave AC voltage smaller than the DC voltage.

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34. The display device according to claim 20, wherein the partition wall also serves as the partition wall-side electrode.

35. The display device according to claim 20, wherein the partition wall partitions the pixels into a hexagonal shape when viewed in plan.

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36. The display device according to claim 2 or 20, wherein at least one kind of the charged colored particles are porous particles.

37. The display device according to claim 2 or 20, wherein at least one kind of the particles is composed of particles composed of core particles and micro-particles having a diameter of from about 1/1000 to about 1/100 of the diameter of the core particles and fixed to the core particles in a manner to cover the surface of the core particles.

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38. The display device according to claim 2 or 20, wherein the surfaces of the particles, or at least a portion of the surface of a member on which the particles adhere are subjected to a water-repelling treatment.

39. A method of manufacturing a display device, including a pair of

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substrates opposed to each other and provided with electrodes, at least one of the substrates is light-transmissive and at least one of the electrode is formed on at least one surface of the substrates, a spacer formed between the substrates for retaining a space having a desired width, at least one kind of group of electrostatic particles contained in the space between the substrates, and a vibration generating portion provided so as to face the space in which the group of particles travel, the device being configured to display an image corresponding to an image signal voltage applied to the electrodes by causing the group of particles to travel in the space between the substrate by an electric field produced by the image signal voltage, the method comprising:

a step to contain the group of particles in the space between the substrates; and

a step to generate vibration by the vibration-generating portion after the particles containing step.

40. A method of manufacturing a display device, including a partition wall for partitioning into pixels a space formed between a pair of opposed substrates, at least one of which is transparent, substrate-side electrode connected to a voltage applying means and provided on an inner surface of at least one of the substrates for each of the pixels, and a partition wall-side electrode provided on the partition wall for each of the pixels and connected to the voltage applying means, the device being configured to display an image corresponding to an image signal voltage by causing at least one kind of plural charged colored particles internally existing in the space to travel in

the space by an electric field produced by the image signal voltage applied to at least the substrate-side electrode, the method comprising:

a step to contain at least one kind of plural charged colored particles in the space; and

- 5 a step to apply an AC voltage to at least the substrate-side electrodes to generate an alternating electric field in the space after the particles containing step.